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APPARATUS FOR STUDY OF THE STRENGTH OF LARGE BOLTS

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APPARATUS FOR STUDY OF THE STRENGTH OF LARGE BOLTS

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*Better to
re-analyze into
final report
for*

References

1. Hetenyi, M. Handbook of Experimental Stress Analysis 1950
2. Ind. Fasteners Institute "Strength of Large Bolts" Fasteners, Vol. 5 No. 2 1948
 "Standard Tests for Bolts and Nuts" Fasteners, Vol. 5 No. 3 1948
 "Safety Factors in Screw Thread Assemblies" Fasteners, Vol. 6 No. 2 1949
 "Determining Bolt Load Elongation Curves" Fasteners, Vol. 6 No. 4 1950
3. Whittemore, H. "Impact and Static Tensile Properties of Bolts" U.S. Bureau of Standards, Nussbaum, G. Journal of Research, Vol. 14 1935
 Seaquist, E.
4. Goodier, J. "The Distribution of Load on the Threads of Screws" Journal of Applied Mechanics, Vol. 7 No. 1 1940

I. INTRODUCTION

a. Purpose of Report

7 This report was written to present the different types of apparatus used for the study of the tensile and stripping strength of large individual bolts. The scope of the material includes a discussion of the apparatus used in the project, "The Strength of Large Bolts", now being conducted at the Fritz Engineering Laboratory and other apparatus used in similar tests. Its object is not to present the various phenomena and results obtained from the test specimens in the project or in similar tests.

b. History of Project

In 1947, Bethlehem Steel Co. had constructed a 10-million cu. ft. wet-type gas holder. Bracings for the lower tier of the columns were designed for $3\frac{1}{2}$ inch diameter threaded rods. These rods were tested in the 800,000 lb. Testing Machine at the Fritz Engineering Laboratory. They failed before reaching the design load which was based on the tensile strength of the rods. Failure was due to stripping of the nuts. A project "The Strength of Large Bolts", was started to investigate the occurrence of tensile and stripping failures in large bolts.

c. Project Objectives

Mr. Jonathan Jones on his article "Strength of Large Bolts", summarizes the project objectives with these two questions; "(1) whether the phenomenon varies as between small and large bolts in accordance with any discoverable law, and (2) if it does, whether the height of the nuts for larger diameters should be increased to develop the full tensile value of every bolt."

d. Reference to Previous Work

A literature survey on this study provided no direct results. However, some material such as the general behavior of bolts and nuts when subjected to tension were helpful in analyzing the problem considered.

II. SELECTION OF APPARATUS

a. Testing Machines

Pilot tests on small diameter bolts, (1 inch and $1\frac{1}{2}$ inch diameter) were used instead of the actual size tested. This suggests the use of a smaller Testing Machine and a more economical test specimen. For the 1 inch dia., a 60,000 lb. capacity Universal type, Hydraulic Testing Machine was utilized. A similar 300,000 lb. capacity Testing Machine for the $1\frac{1}{2}$ inch dia. bolts. Controlled rate of loading is a factor in running tests as slow rate application of loads produces strain hardening effects in the specimens. These machines are found to be satisfactory for the test specimens in the project. ?

b. Instruments

Measurements of longitudinal elastic strains were taken by using Huggenberger Tensometers having 1 inch gage lengths. It is a highly sensitive apparatus and has an accurate gage for strain measurements but due to its very short measuring range, its use was limited to the elastic region. These strain

readings in the Tensometers were checked by also using a Tuckerman optical gage on these specimens.

A Moore Extensometer of 2 inch gage length was substituted for the Huggenberger gages when tests were continued in the plastic region. Its advantage over the Huggenberger gages is that; (1) the Moore Extensometer, having a high range of deformation eliminates the inconvenience of resetting the gages; (2) the Moore Extensometer is easier to set on the specimen.

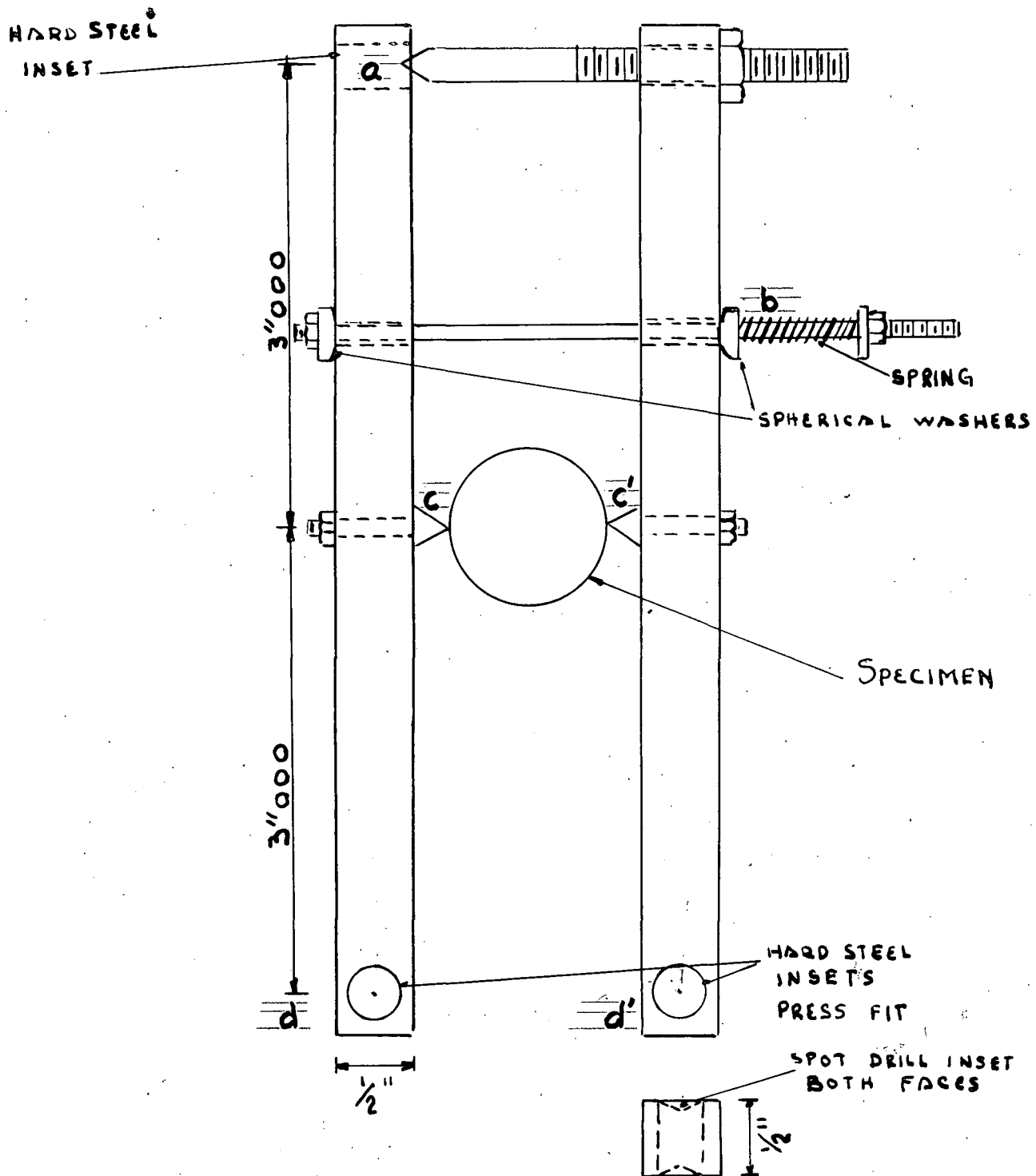
III. DESIGN OF AUXILIARY EQUIPMENT

a. Radial Elongation Gage

To determine the amount of transverse strains a "Radial Elongation Gage" type of apparatus shown in fig. 1 was designed. Its principal of operation is based on the mechanical lever system type of gage. *by whom?*

Point a acts as the fulcrum of the lever. Distance c-c' reduces an amount equal to the transverse strain. Distance d-d' reduces to twice the amount c-c' reduces. A spring is attached at b to keep the conical pointed screw at a in contact with the gage frame.

The R.E.G. was combined with a Peter's Stress Strain Recorder, contact points being made at d-d'. The Recorder had a revolving drum attachment which plotted the actual strain values using different scales of magnification as when testing the specimen from the elastic to the plastic range.



REG
RADIAL ELONGATION GAGE

FIG. 1

b. Root Diameter Measuring Device

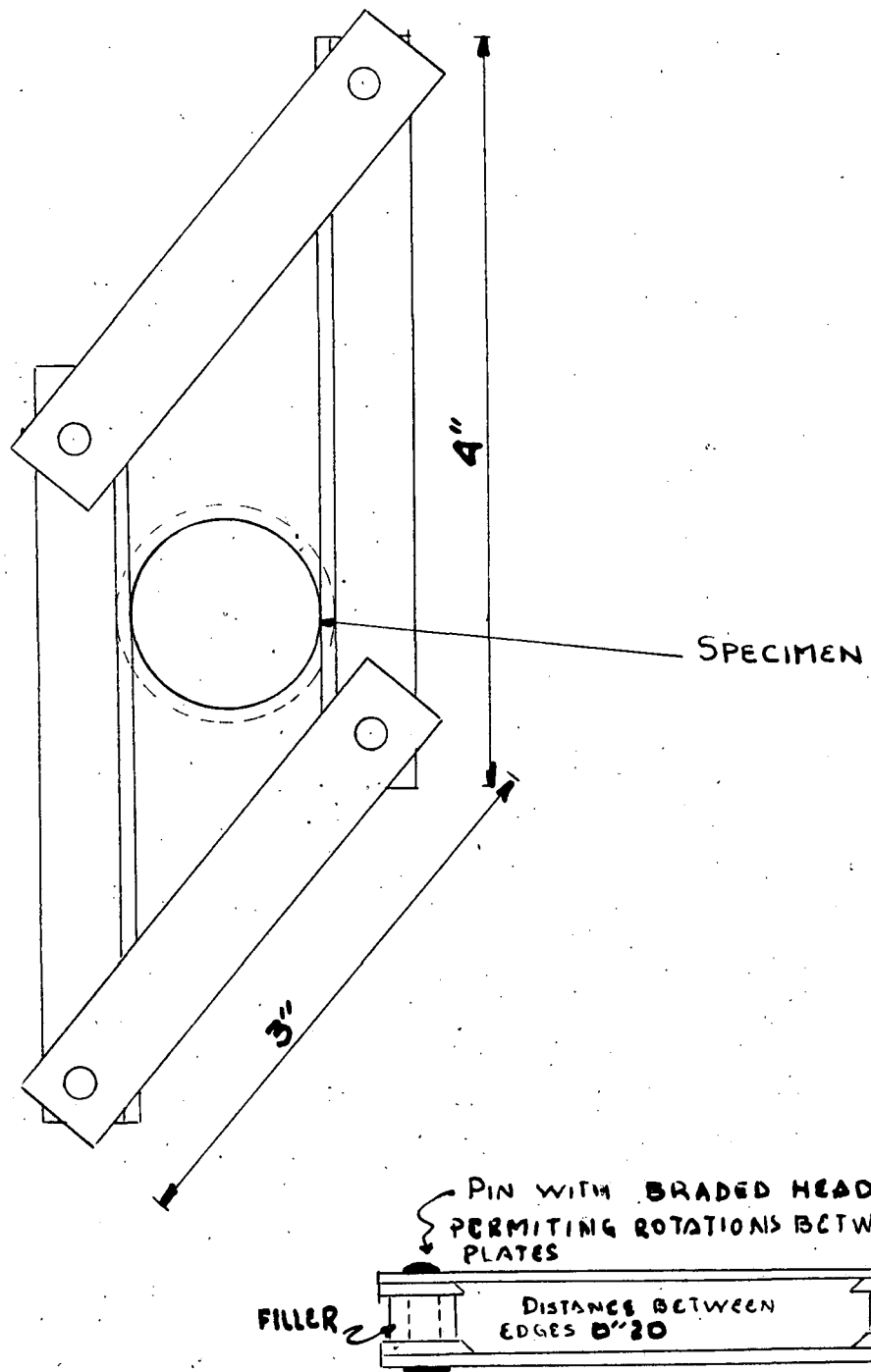
The problem of determining the actual root diameter of the bolts was made possible by designing a simple device as shown in fig. 2. This Root Diameter measuring device is used in combination with a micrometer.

With the gaps closed, a micrometer reading was taken on two opposite side plates. The device was opened and the plates are placed in contact with the grooves of the threaded portion of the specimen as shown. Micrometer readings are again taken on the same two opposite side plates. The difference between the two readings gives the actual root diameter of the bolt. The plates are sharpened on the inner side to avoid forming clearances between the plate and the groove surfaces of the bolt.

IV. INSTRUMENTS USED IN SIMILAR TESTS

a. Lateral Extensometer

The instrument shown in fig. 3 was designed to measure lateral strains for a project called "The Distribution of Loads on the Threads of Screws", by J. N. Goodier. It is similar to the E. H. Lamb's (4) roller extensometer except in the attachments of the movable block b to the frame of the instrument. The attachments were modified by using arch springs instead of steel balls in the grooves as in the Lamb's (4) roller extensometer. The block b moved due to radial contractions. This motion was transferred to rotation of a pair of mirrors on each side of the block.



DEVICE FOR MEASURING ROOT
DIAMETER OF BOLTS

FIG. 2

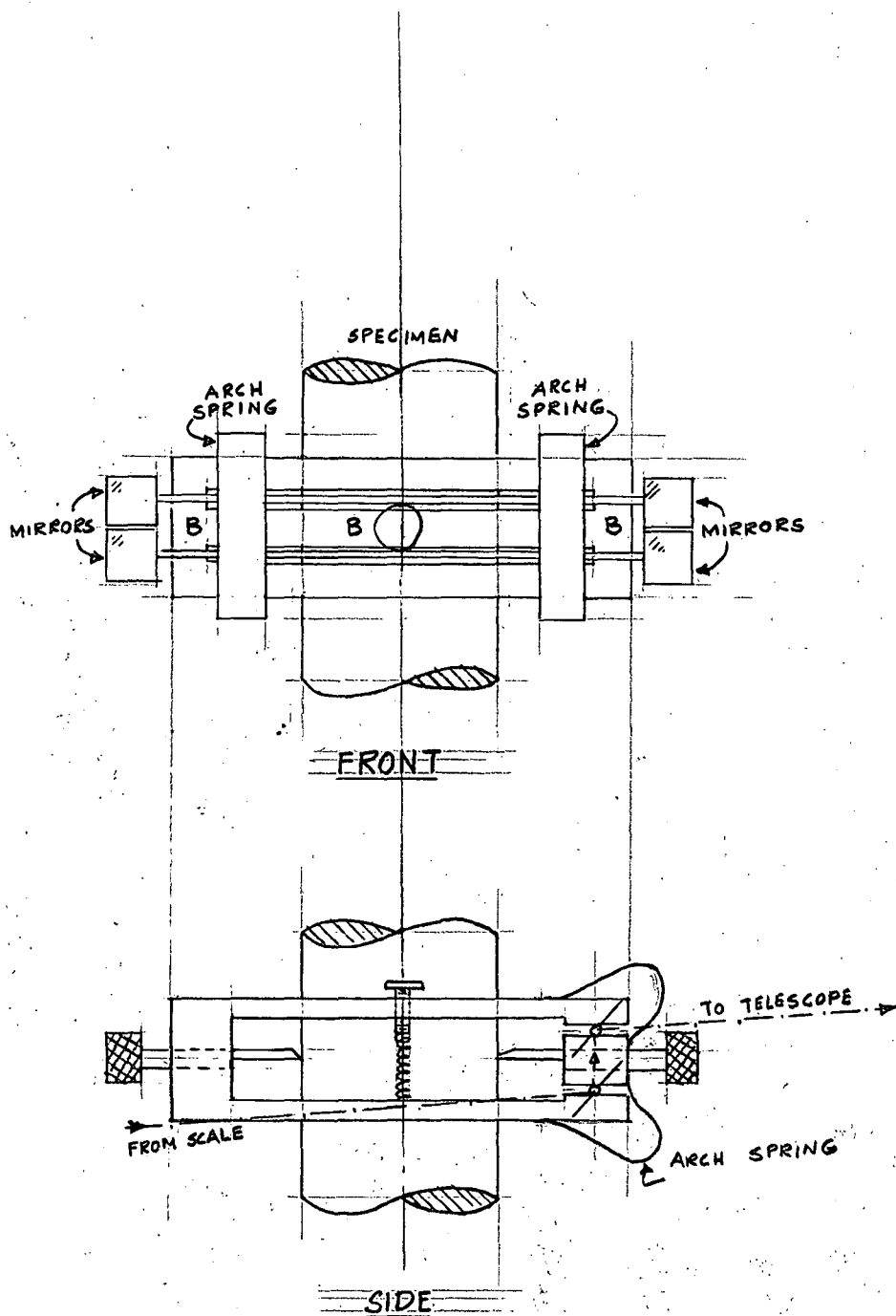
Measurements were taken by observing through a telescope the change in the scale readings due to rotation of the mirrors. The average of the two measurements taken at each end would be the correct strain reading.

b. Fixture for Measurement of Obliquity of Face of Nut

The instrument shown in fig. 4 was taken from a report, "Impact and Static Tensile Properties of Bolts". The nuts were screwed on a mandrel located on the center axis of the instrument. A dial micrometer with contact point on the bearing face of the nut was attached. If the readings did not change when rotating the mandrel, this would mean that the bearing face of the nut was perpendicular to the longitudinal axis.

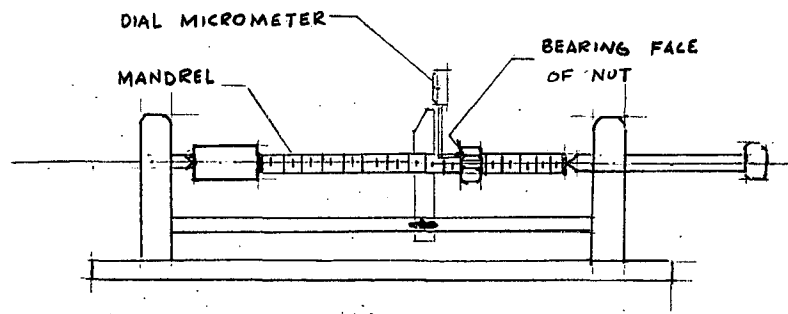
c. Fixture for Measurement of Diametrical Clearance between Nut and Bolt.

This instrument shown in fig. 5 was also taken from the same report described in part (b.). Using a dial micrometer resting directly over the axis of the nut, the nut was given a small upward force and rotated thru a small angle. The minimum micrometer reading was recorded. The procedure was repeated using a small downward force. The difference between the two readings would give the diametrical clearance between nut and bolt.



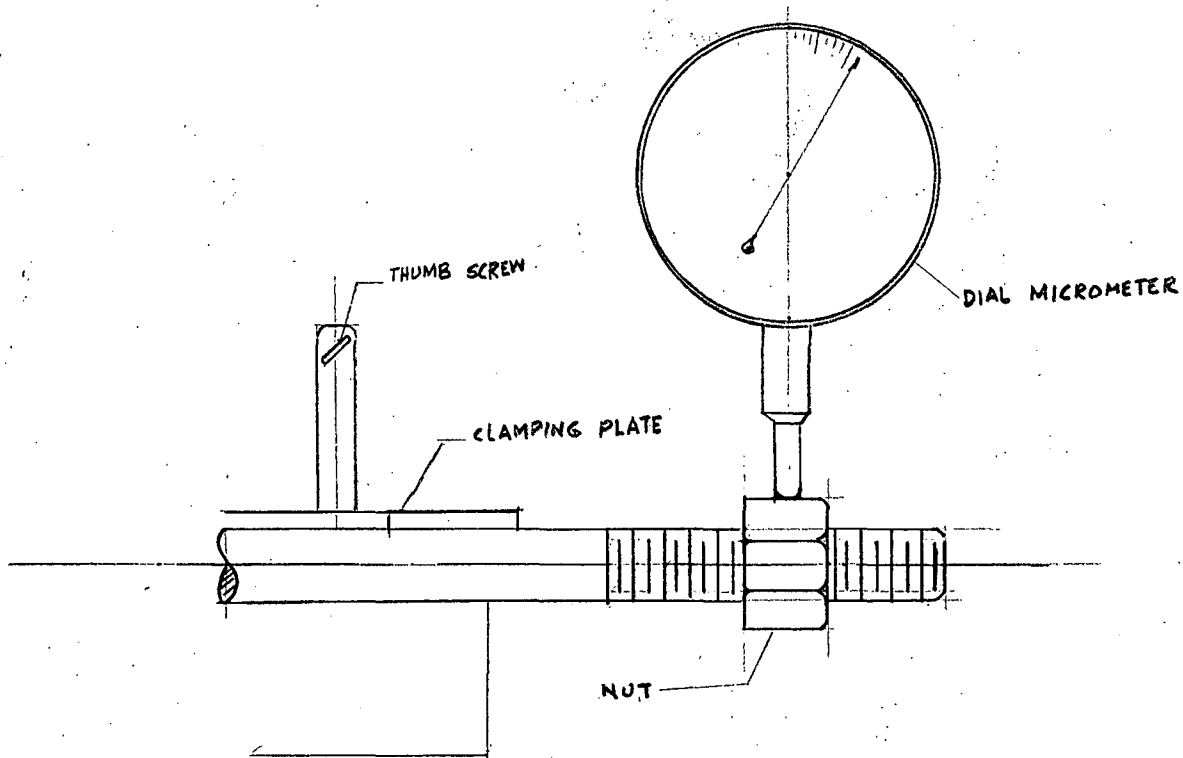
LATERAL EXTENSOMETER

FIG. 3



FIXTURE FOR MEASUREMENT OF OBLIQUITY OF FACE OF NUT

FIG. 4



FIXTURE FOR MEASUREMENT OF DIAMETRICAL CLEARANCE BETWEEN NUT & BOLT

FIG. 5

V. TEST SET-UP

what is a "B" test?

a. B-Test

Specimens for the B-Test were prepared by threading a unit length on the center portion of the stud. No nuts were used.

The specimen was placed longitudinally between the cross-heads of the Hydraulic Testing Machine using standard vee-grips to hold the ends firmly.

The Huggenberger Tensometers were placed symmetrically, one on each side of the specimen. Any error due to a possible eccentric loading will be eliminated by taking the average of the two readings. A similar set of readings were taken by using a Tuckerman optical gage on the specimen.

While working in the plastic region, the Huggenberger gages were removed and substituted with a Moore Extensometer.

The Radial Elongation Gage was located immediately below the extensometers. This was made possible by scribing two lines, 180 degrees apart, on the specimen while they were machined.

All measuring devices were removed from the specimen when there was an indication of ultimate failure of the specimen.

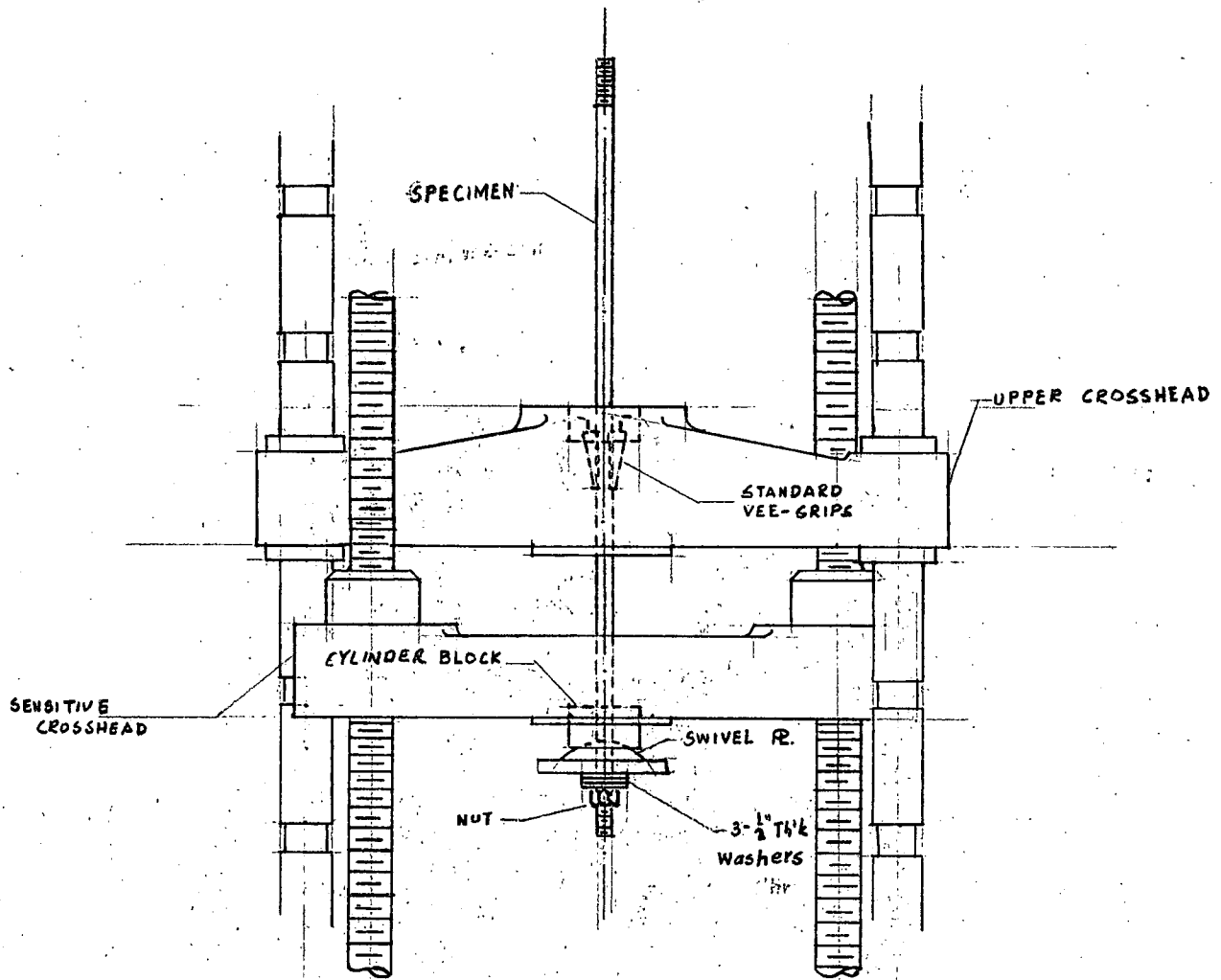
b. P-Test

For the P-Test, the specimens were of a nut and bolt assembly and threadings were made on each end of the stud.

A test set-up, as shown in fig. 6, was used for tensile and stripping failures of the nut and bolt assembly. A swivel plate and cylinder block on the sensitive crosshead was used to eliminate

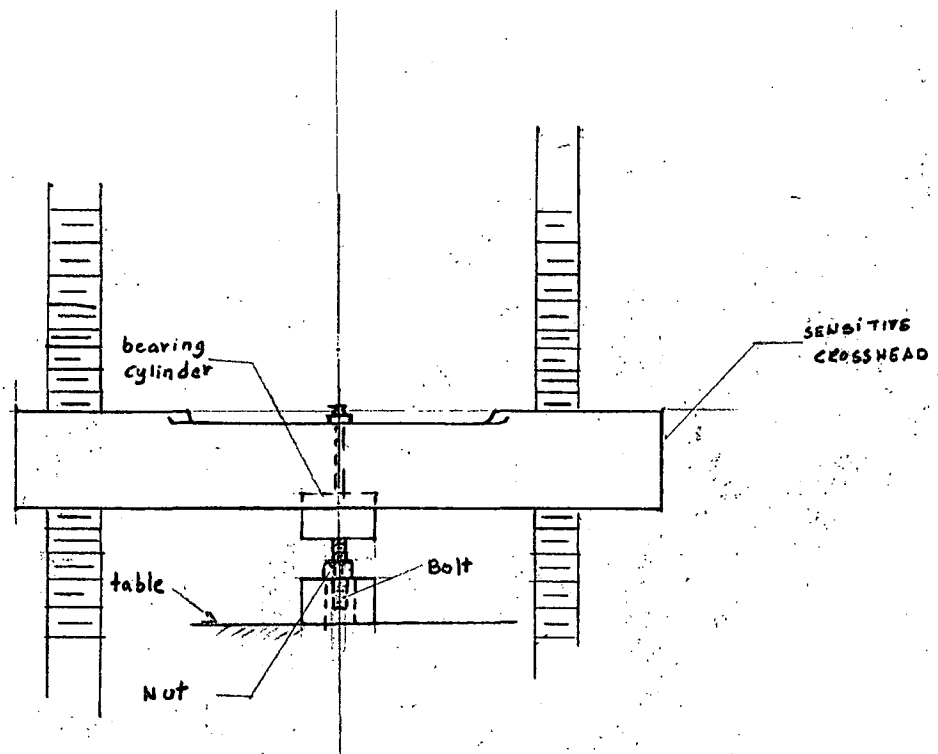
any eccentric loading due to incorrect alignment in setting the specimen. Washers were used to provide the nuts with sufficient bearing area. No strain measuring devices were attached.

Fig. 7 shows a method designed to find the stripping values of the specimens that failed in tension (using the set-up described above). The sensitive crosshead presses on the bolt and tends to push out the bolt from the nut. Due to the fact that the bolt "swells" in the nut, the recorded stripping values are higher than in an actual case.



SET-UP FOR "P-TEST"

FIG. 6



"PUSH-OUT" TEST

FIG. 7